GUIDELINES

FOR

STRUCTURES FOUNDATION REPORTS

VERSION 2.0

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Caltrans

DIVISION OF ENGINEERING SERVICES
GEOTECHNICAL SERVICES

CONTENTS

1. INTRODUCTION

1.1 Purpose

The following information provides guidelines for typical structure foundation investigations and foundation reports for the California Department of Transportation (Caltrans).

The Offices of Geotechnical Design North, South 1, South 2, and West, of Geotechnical Services (GS), Division of Engineering Services, Caltrans, are responsible for performing and providing foundation recommendations along with providing geotechnical oversight of these foundation investigations and reports. The four Offices of Geotechnical Design will also act as the single points of contact representing GS with the Offices of Special Funded Projects (OSFP), Structures Contract Management (OSCM), and other Caltrans offices.

Any deviation from these following guidelines should be documented by the report author and approved by the Geotechnical Design Office Chief.

1.2 General Requirements

Foundation Investigation is required for all structures (bridges, tunnels, retaining walls, soundwalls, tieback walls, MSE walls, overhead signs, maintenance stations, pumping plants/stations, toll plazas, etc.) when new, widening, retrofit, or modifications to existing structures are proposed. Refer to Topic 829 of the *Highway Design Manual* (Caltrans, 2001) for direction regarding the need for Structure Foundation Reports for culverts. Foundation Investigation generally consists of three stages: A Preliminary Geology Report to support Advanced Planning Studies, Preliminary Foundation Recommendations to support Type Selection, and Foundation Recommendations to support the design of the structure and construction. (The Preliminary Geotechnical Design Report and Geotechnical Design Report for the roadway portion of a project shall be submitted separately from Structure Foundation reports.)

The Foundation Investigation shall be conducted and the Foundation Report developed by a Registered Civil Engineer or Registered Geologist who specializes in foundation engineering for highway structures. The geotechnical professional of record shall include his/her State of California registration seal, license number, registration certificate expiration date, and signature on all submittals of Foundation Reports, addenda and/or amendments to the Foundation Reports, and Log of Test Boring (LOTB) sheets.

The Foundation Report shall be developed in accordance with Caltrans requirements including the guidelines herein. It shall also conform to generally accepted standards of professional practice and all applicable rules and regulations of the California Board of Registration for Professional Engineers and Land Surveyors and the California Board of Registration for Geologists and Geophysicists.

The Foundation Report shall consist of, but not be limited to, the following: cover sheet, table of contents, main contents, and appendices. The cover of Foundation Reports and numbered addenda/amendments to Foundation Reports shall include the following

information: Caltrans District, County, Route, Kilometer Post (KP) Total Project Limits, State-assigned Bridge (or Structure) Number, State-assigned Bridge (or Structure) Name, and Expenditure Authorization (EA) number. All LOTB sheets submitted shall also contain the above information.
(For internal Caltrans documents the following items do not need to be included within the Foundation Report; the cover sheet and a table of contents.)

The Foundation Report shall address, but not be limited to, the following topics when applicable: scope of work, project description, field exploration, laboratory testing, site geology and subsurface conditions, groundwater conditions, geologic profiles and engineering parameters, seismic study, liquefaction evaluation, scour evaluation, corrosion evaluation, foundation recommendations, approach fill earthwork, settlement, slope stability analyses, and construction considerations.
(For internal Caltrans documents the following items do not need to be in the Foundation Report; laboratory testing, engineering parameters, geologic profiles, approach fill earthwork, and slope stability analysis. The above listed items are to be archived in the bridge folders.)

The Foundation Report shall contain foundation recommendations that are complete and concise. The recommended foundation type shall be cost-effective, performance-proven, and constructible.

It is Caltrans practice that existing structure foundations shall be evaluated according to the latest Caltrans design criteria when widening or retrofitting projects are initiated. The evaluation shall be made prior to the Type Selection Meeting and conclusions shall be included in the Type Selection Report/Preliminary Foundation Report. Foundation reports for projects previously approved by Caltrans but that have been shelved shall be updated and reviewed and approved by Caltrans in accordance with the latest Caltrans requirements when necessary.

It is imperative that the structural designer, geotechnical professional, engineering seismologist, corrosion engineer, hydraulics engineer, and specifications engineer maintain close communication during the development of the Foundation Report, Contract Plans, and Special Provisions. Foundations as shown in the Contract Plans and discussed within the Special Provisions shall be consistent with the Foundation Report.

Log of Test Boring (LOTB) sheets shall be drafted and submitted as part of the Foundation Report and are to be included within the Contract Plans. As-Built LOTB sheets, when available, shall also be submitted as part of the Foundation Report and included within the Contract Plans.
(For internal Caltrans documents the LOTB sheets and As-Built LOTB sheets are not to be submitted as part of the Foundation Report. Copies of these items are to be archived in the bridge folders. Both the Microstation LOTB files and scanned copies of the As-Built LOTB sheets are to be sent to the designer for inclusion within the Contract Plans and a copy is to be archived within the bridge folder by drafting services.)

2. PRELIMINARY FOUNDATION REPORTS

A Preliminary Foundation Report (PFR) is required during the early stages of a project and shall be included as part of the Advanced Planning Study and Type Selection submittal. The PFR is used to document existing foundation conditions, make preliminary foundation recommendations, and identify the need for additional investigations and studies. The PFR shall provide, but not be limited to, the following:

2.1 Project Location

The structure's location-shall be included and discussed in the PFR.

2.2 Summary of Site Geology and Subsurface Conditions

This section shall provide a description of the project site, geology and known existing subsurface conditions. The site data may come from current or past field investigations at or near the structure site, As-Built documents, maintenance records, construction notes and any relevant information that is available. The information included within this section shall include but not be limited to:

1) Topography and geology,
2) Types of soil/rock,
3) Pertinent soil conditions or geologic hazards,
4) Depth to the bedrock, if known,
5) Groundwater elevation(s) and dates the measurements were made.

If these conditions are based on an extrapolation from information at a nearby site, this fact shall be noted and the applicability of the information to the project site shall be addressed.

2.3 Scour Evaluation

The geotechnical professional shall incorporate the hydraulic findings outlined in the structure Hydrology/Hydraulics Report with geologic and geotechnical information to make recommendations regarding the potential scour depth.

(For internal Caltrans documents, the hydraulics report is produced later in the design and only provides depth of historical or potentially scourable materials.)

2.4 Corrosion Evaluation

The PFR shall include any available corrosion data for the site and a discussion of such data. If corrosion data for the site is not available, or is insufficient to provide conclusive information regarding the corrosiveness of the site, additional corrosion sampling and testing shall be required per Caltrans guidelines. Corrosion Guidelines (Caltrans, 2003) may be obtained from the Corrosion Technology Branch, of Materials Engineering and Testing Services, Division of Engineering Services, or on-line at "www.dot.ca.gov/hq/esc/Translab/metspubs.htm".

2.5 Preliminary Seismic Study

Seismic study shall be conducted as early as possible and shall address ground motion, soil liquefaction, surface fault rupture potential, seismic settlement, and seismic slope instability. The current Caltrans Seismic Design Criteria (SDC), Memo To Designer (MTD) Section 20, and Caltrans California Seismic Hazard Map (CCSHM) shall be the basis for specifying the minimum seismic design requirements for Ordinary Standard Bridges. For definition of Ordinary Standard Bridges refer to SDC Section 1.1. Other well-documented references may be used for seismic study. For important bridges as defined in MTD Section 20-1, the requirements of project specific design criteria shall be met. If some of the information as indicated below could not be ascertained for the preliminary report, it may be deferred to the final foundation report.

2.5.1 Ground Motion Study

The report shall include but not limited to the following seismic ground motion information:

1) Designation of controlling active fault(s), style of faulting, magnitude of Maximum Credible Event (MCE), fault-to-site distance, and the Peak Bedrock Acceleration (PBA);
2) Soil profile type as defined in SDC Appendix B;
3) Recommended Acceleration Response Spectra (ARS);
4) If applicable, site-specific seismic hazard evaluated using site response analysis and design ground motion time-history; and
5) If necessary, recommendations for in-situ data acquisition and laboratory testing needed for site-specific study; such as necessary depth of borings, gradation, wave velocities, strain dependent shear moduli and damping ratios.

In the implementation of the above requirements the following points shall be noted:

- The value of PBA ascertained from CCSHM shall be verified with that calculated using Geomatrix (1997) attenuation relation.
- Soil profile type shall be based on the top 100 feet depth of soil.
- The Standard ARS curve from SDC Appendix B shall be modified for near-fault directivity effect and the depth of alluvium as explained in SDC Section 6.1.2.
- Site-specific seismic ground motion study may be required for bridges located at or near fault, for soil profile type F, for long period structures, for long bridges with length exceeding 1000 feet, or other special cases. For long bridges the spatial variability of the ground motion shall be considered.

2.5.2 Liquefaction Evaluation

The report shall include an assessment of the soil liquefaction potential at the project site and its effects on the existing and/or proposed foundations. Special care should be given to the potential for lateral spreading and the assessment of the kinematic forces that may be exerted on the foundation as the result. If the potential for liquefaction is suspected then field and laboratory program to obtain reliable data for a more definitive quantitative evaluation of the liquefaction potential and consequences shall be provided. For the assessment of liquefaction potential the consensus report on liquefaction [1] may be used.

2.5.3 Fault Rupture Study

Caltrans Surface Fault Rupture Displacement Hazard Guideline shall be the basis for this study. This Guideline is currently posted on the Caltrans website and is to appear in Memo To Designer. The study shall identify if a potential for Surface Fault Rupture Displacement Hazard (SFRDH) exists and assess the location, magnitude, and orientation of the static offset. If the potential for surface fault rupture within the project site is remote, it shall be noted in the report.

The potential for SFRDH shall be considered where any portion of a bridge falls within California Geological Survey (CGS) Fault-Rupture Hazard Zones (Alquist-Priolo Earthquake Fault Zones). If a bridge falls within Fault-Rupture Hazard Zones, further study should be conducted to ascertain if SFRDH should be considered for design. This study may include field visit and review of aerial photos and geological maps to identify if traces of a fault may cross the bridge. If a trace of fault is identified in the field, then a setback of minimum 50 feet horizontal distance from the trace should be considered as having potential for SFRDH. Geotechnical Services in consultation with the Office of Earthquake Engineering shall make the final determination if the potential for SFRDH is to be considered.

Where the existence of a seismogenic fault (not included in CGS Fault-Rupture Hazard Zones) as defined by the Caltrans California Seismic Hazard Map and having activity within the Holocene period is suspected, Geotechnical Services in consultation with the Office of Earthquake Engineering, shall make the determination if further study including a site-specific field investigation on SFRDH is warranted. If the decision is made to conduct a site-specific study, the procedures as outlined in CGS Note 49 shall be followed.

2.5.4 Seismic Settlement

The potential for seismic settlement and its impact on foundation design shall be included in the report.

2.5.5 Seismic Slope Instability

The potential for slope instability in the form of landslides, mudslides, or rockslides as related to safety and performance of the bridge shall to be addressed in the report. For evaluation of seismic slope stability refer to Section 3.11 of this guideline.

2.6 As-Built Foundation Data

The PFR shall include, but not be limited to, evaluation of the following As-Built data:

1) As-Built and any other applicable LOTB sheets;
2) As-Built plans showing existing types of shallow or deep foundations, abutments, etc.;

   (For internal Caltrans documents: Items 1 and 2 do not need to be included within the FR, but do need to be archived in the bridge folders.)
3) As-Built geotechnical ultimate compressive, tensile, and lateral capacities of existing foundations shall be estimated and discussed when applicable.
4) Recommendations for the ultimate lateral passive resistance of soil located behind abutments shall be provided if applicable; and

5) Construction records such as pile driving logs, pile load test reports, settlement monitoring data, groundwater monitoring notes, etc.

Based on the evaluation of existing data, recommendations for any additional field investigation shall be made. If additional field explorations are necessary, the scope and types of fieldwork shall be stated.

2.7 Preliminary Foundation Recommendations

The PFR shall provide preliminary foundation recommendations and foundation types for the proposed structure based on the geological and soils data available at the proposed structure site. Any foundation types that are not applicable or constructible should be mentioned and discussed.

2.8 Additional Field Work and Laboratory Testing

The PFR shall state the scope and type of fieldwork along with any laboratory testing that will be required to develop final foundation recommendations. It is prudent to plan in advance and obtain sufficient support-location specific soil/rock information.

3. FOUNDATION REPORTS

Consultant-prepared Structures Foundation Reports shall be submitted as early as possible to Caltrans for review and approval. Technical discussions between the consultant and Caltrans reviewer are encouraged during any stage of the project development.
The Foundation Report shall address, but not be limited to, the following topics when applicable:

3.1 Scope of Work

This section shall summarize the scope and types of work performed to obtain the information supporting the foundation recommendations.

3.2 Project Description

This section shall describe the project location, existing and/or proposed structure(s), and pertinent project information. The datum used to reference the elevations in the report should be included. A site vicinity map indicating the project location shall be included in the Appendices.
(For internal Caltrans documents, A site vicinity map does not need to be included in the FR, but does need to be archived in the bridge folder.)

3.3 Site Geology and Subsurface Conditions

This section shall provide a description of the project site, geology and known existing subsurface conditions. Historical and/or potential geologic hazards such as landslides and other slope failures, ground subsidence, collapse, heave, and faults shall be characterized. The site data may come from current or past field investigations at or near the structure site, As-Built documents, maintenance records, construction notes and any relevant information that is available. The information included within this section shall include but not be limited to:
(Discussions pertaining to groundwater and what was encountered during the field investigation need to be addressed in a section titled “Groundwater”)

3.3.1 Topography and geology.

When potential landslides or other failures pose hazards to the foundations, detailed terrain analysis, structural features study, and other geologic investigations shall be performed. Remediation measures shall be presented. Structure foundations shall not be used as any part of the landslide remediation measures.

3.3.2 Pertinent soil conditions or geologic hazards.

If soil conditions such as Collapsible Soils, Corrosive Soils, Expansive Soils, Frost Heave Susceptible Soils, Frozen Soils, Liquefiable Soils, or Sanitary Landfill are encountered at the project site, this information from field exploration and laboratory tests, including groundwater and index properties of soils, shall be documented. Effects of these problematic soils on foundations and the proposed mitigation measures shall be discussed when developing foundation recommendations.

3.3.3 Project Site Soils **(This section is currently being updated)**

A discussion of the soil types that will be encountered during construction is to be included here.

3.3.4 Project Site Rocks

The following information for bedrock shall be addressed:

a) If bedrock is encountered in the field study, the elevations and locations shall be included. (Note: Continuous coring is required in bedrock; see *ASTM D 2133.*)
b) Where rock-mass discontinuities are relevant to the design, construction, or performance of the foundation, the following shall be addressed:
    i) Type of fracture(s) (fault, bedding plane, foliation, and joint)
    ii) Orientation of fracture(s) (dip, dip direction, and strike)
    iii) Stereographic projection (pole plots, density, and great circles), and Kinematic analysis (planar failure, wedge failure, toppling failure, etc.).

3.4 Ground Water

Groundwater elevation(s) and dates and locations the measurements were made. If artesian ground water was encountered during past or previous investigation it needs to be discussed and addressed here.

3.5 Scour Evaluation

The geotechnical professional shall incorporate the hydraulic findings outlined in the structure Hydrology/Hydraulics Report with geologic and geotechnical information to make recommendations regarding the depth of potentially scourable material.
(For internal Caltrans documents the hydraulics report is not to be included within the foundation report. A copy of the hydraulics report is to be archive in the bridge folder. The geotechnical designer is only to provide depth of historical or potentially scourable materials in the foundation report.)

3.6 Corrosion Evaluation

This section shall contain an assessment of the corrosiveness of a site based on the review of relevant corrosion test data. Corrosion test data shall be included in Appendices. **(For internal Caltrans documents, this data is archived in the bridge folder, not the foundation report.)** The actual corrosion test results are to be provided in tabular form in this section. For an example of a soil corrosion data table refer to Section 5, Figure 5.1. Sufficient information regarding the number and location of soil borings for corrosion testing shall be included to allow a thorough review of the recommendations.

3.7 Seismic Study

The final foundation report shall include and update those materials covered in the preliminary foundation report based on the new findings and from field investigations. It shall address seismic ground motion, soil liquefaction, surface fault rupture potential, seismic settlement, and seismic slope instability.

If requested by the Structural Design, the report shall provide nonlinear soil springs (the so-called py, tz, and qz curves) for soil layers and/or the foundation stiffness matrix. The lateral load analysis of pile foundations and the pile tips controlled by lateral load shall be provided if requested by Structural Design.

3.8 As-Built Foundation Data

The FR shall include, but not be limited to, evaluation of the following As-Built data:

1) As-Built and any other applicable LOTB sheets;
2) As-Built plans showing existing types of shallow or deep foundations, abutments, etc.;
   (For internal Caltrans documents: Items 1 and 2 do not need to be in the foundation report, but do need to be archived in the bridge folders.)
3) As-Built geotechnical ultimate compressive, tensile, and lateral capacities of existing foundations shall be estimated and discussed. Recommendations for the ultimate lateral passive resistance of soil located behind abutments shall be provided if applicable; and
4) Construction records such as pile driving logs, pile load test reports, settlement monitoring data, groundwater monitoring notes, etc.
   (The above section needs to be copied from the PFR so the this information will be included within the materials handout with the foundation report)

3.9 Foundation Recommendations

Complete and concise foundation recommendations shall be provided for the referenced structure. The selection of a specific foundation type depends on factors such as surface and subsurface conditions at the site, geotechnical capacity, dynamic and static demands, environmental concerns, economics, and construction issues. The recommended foundation type shall be cost-effective, performance-proven, and constructible. When applicable, alternative foundation types shall be discussed and the reasons why those alternatives are not recommended shall be stated. Solutions to potential construction problems shall be discussed.

In general, any foundation design shall meet the following criteria.

1) The soil/rock surrounding the foundation is to have adequate geotechnical capacity and or strength to meet or exceed the specified safety against ultimate failure
2) Total and or differential settlements under static and dynamic loads are with in predetermine tolerable acceptable limits for the structure
3) The foundations must be constructible.

3.9.1 Shallow Foundations.

The geotechnical professional shall address, but not be limited to, the following when applicable:

1) Bearing/Lateral Capacity
   a) The required minimum footing width (B), length (L), and minimum depth (D) at the bottom of footings or the maximum elevation at the bottom of footings

   b) Effects of soil density, groundwater table, seepage, load eccentricity and/or inclination, or layered soils on bearing capacity
   c) Foundations on slopes, adjacent to slopes, or with inclined bases
   d) Foundation failure modes where foundations are founded on or embedded into rock.
2) Total, Differential, and Tolerable Settlements
   a) Total and differential footing settlement shall be tolerable for both static and seismic loading.
   b) Differential settlement across and between supports shall not exceed 13 mm (0.5 inch). (BDP Sect. 5)
      i) For multi-span structures and single-span structures with end-diaphragm abutments total settlement shall be less than or equal to 25.4 mm (1 inch), and differential settlement shall be less than or equal to 13 mm (0.5 inch).
      ii) For single-span structures with seat type abutments, total settlement shall be less than or equal to 50.8 mm (2 inches) and differential settlement shall be less than 50.8 mm (2 inches).
      iii) For an extreme limit state, with seismic loading, foundations are designed so that settlement during a seismic event will not exceed levels that will cause a collapse.
      iv) For an extreme limit state, with hydraulic scour, foundations are designed so that hydraulic scour during 100-year design flood event will not cause a collapse.

3) Overall stability of slopes in the vicinity of a footing under both working loads and seismic loads.

4) Other Considerations for Shallow Foundations
   a) For freezing ground, see BDS Sect. 4)
   b) The top of footings or other shallow foundations shall be founded at or below the maximum anticipated depth of scour at water crossings.
      Maximum depth = 100% degradation plus local pier scour.
   c) Where footings are placed adjacent to existing structures, the effect of the existing structures on the performance of the new footing and the influence of the new footing on the adjacent structures, including construction activities, shall be discussed.
   d) When footings are subject to uplift forces, footings shall be evaluated for resistance to pullout.

5) The Spread Footing Data Table is to be shown in the foundation report, for details refer to Section 5, Figure 5.2 for an example and Memos to Designers Section 4 for the most current format.

3.9.2 Deep Foundations, the geotechnical professional shall address, but not be limited to, the following when applicable:

1) Pile Types, Bearing Capacity.

a) For standard foundation design, Caltrans Standard Class 400, 625 and 900 piles (*Standard Plans* (Caltrans, 1999)) should be used. Refer to the Standard Plans for the maximum allowed loading per pile.
b) The foundation report must state how the geotechnical capacities are derived; whether from skin friction, end bearing, or a combination of both
c) Pile Design Tip Elevations (DTE) are to be determined for each of the following loadings that apply: compression, tension, lateral, scour potential, liquefaction, etc. The pile Specified Tip Elevation (STE) is to be the lowest pile DTE that was calculated.
d) The portion of the axial capacities for pile foundations in and above liquefiable soils shall be neglected.
e) All axial capacities of a pile above the maximum scour depth shall be neglected. (For earthquake loading conditions, refer to Section 4.4.5.2 of *Bridge Design Specifications* (Caltrans, 2000).)
f) Negative skin friction (down-drag) on pile shafts due to settlements of new fills or compressible soil layers shall be eliminated prior to pile installation. Recommendations to induce anticipated settlement along with specific waiting periods and methods to monitor the settlement shall be included.
g) **(This section is currently being updated)**~~When a situation such as liquefaction potential exists that does not allow for mitigation and elimination of negative skin friction, the magnitude of the down-drag forces shall be estimated and provided to the structural designer for him/her to incorporate those forces into Design Loading or Nominal Resistance. The magnitude of estimated settlement shall also be provided to the structural designer. An iterative process may be required between the geotechnical professional and structural designer before the final pile type and diameter is selected.~~
h) **(This section is currently being updated)**~~For piles driven through scourable layers and/or potentially negative skin friction layers, the geotechnical professional shall provide an estimate of the pile driving resistance to reach STE. Non-liquefied conditions shall be considered for pile driving resistance.~~

(Following is an example "Construction Note" containing the information needing to be addressed.)

At Pier Number __ location, the calculated axial geotechnical capacity of the piles above the estimated potential scour elevation of ____ ft, as reported by the Hydraulics Branch has been ignored. When installing the CISS piles at Pier Number __ location, the contractor should anticipate much higher driving resistances than would be indicated by the Nominal Resistances shown in the Pile Data Table for the following reasons:

- The piles will have to be driven through the existing scourable soils above the estimated potential scour elevation of ____ ft.
- The overburden pressure from the existing scourable soils above the estimated potential scour elevation has been ignored when calculating the

axial geotechnical capacity of the piles but will be present at the time of pile installation.

- The calculated geotechnical compressive capacity of the (pile type) pile after installation at Pier Number __ location are calculated to be ____ kips.

i) When overburden pressure from recently placed or proposed fill materials (such as embankments) is used in the static pile capacity calculations, discussion as to how the overburden pressure distribution was modified is to be included. The embankment prism shall not be construed as unlimited.

j) When the PBA is 0.6g or greater, refer to Memos to Designer, Section 5-1 regarding the use of pile foundations for support.

k) When designing piles in a pile group to resist lateral loads, refer to BDS 4.5.6.5.1.

l) Lateral resistance of piles may also be estimated using the p-y method or equivalent. Group reduction factors depending on soil types, pile spacing, and anticipated lateral movement shall be considered when evaluating lateral capacity for a group of piles.

m) Formulation of p-y curves for liquefiable soils and weak rocks, effects of pile diameters on lateral soil modulus and soil strain parameters, evaluation of liquefaction or lateral spreading forces imposed on pile, and reduced moment of inertia for concrete piles shall be addressed when applicable.

n) For tolerable settlement of deep foundations, the maximum vertical movement at the top of a pile is limited to 13 mm (0.5 inch) at the following loads:
   - ASD- at 2 times the design load for compression and tension.
   - LFD- at the required nominal resistances for compression and tension.

   For current maximum allowable pile settlement, also refer to Memos to Designer 3-1.

2) The recommended SPTE and DTE are to be shown in the foundation report, for details refer to Section 5, Figure 5.3 for an example. Refer to Bridge Memo to Designers 3-1 for the most current examples of pile data tables.

3) **Completing/filling out the Pile Data Table (This section is currently being updated to incorporate the "Gates" equations)**~~At locations of bents or piers, a geotechnical professional shall determine pile tip elevations to meet the required **Nominal Resistance**. The geotechnical professional shall convert the required **Nominal Resistance** to a **Design Loading** for driven piles when the Engineering News-Record (ENR) formula is used for field acceptance criteria per Section 49-1 of *Standard Specifications* (Caltrans, 1999d). As such, both converted **Design Loading** and required **Nominal Resistance** shall be shown in the PDT for driven piles. The conversion is not required for the following: if Pile Data Analyzer (PDA) and/or Pile Load Test are proposed for pile installation instead of using the ENR formula, or, CIDH piles are used. Insert "N/A" in the **Design Loading** column in the PDT for these cases.~~

4) Special Considerations for Cast-In-Drilled-Hole (CIDH) Piles
   a) To ensure constructability and quality, the length of CIDH piles should be limited to 30 times the pile diameter. Refer to Memos to Designer, section 3-1.
   b) When battered piles are required, CIDH piles shall not be used. Refer to Memos to Designer, section 3-1 for current requirements.
   c) The following nomenclature is used for CIDH piles:
      - Steel *casings* are used for constructability.
      - Driven steel *shells* are used for pile capacity.

      Refer to Memos to Designer, section 3-1.
   d) Where a steel casing/shell is required, the diameter of the casing/shell shall be at least 200 mm greater than the CIDH pile or rock socket diameter. Refer to Memos to Designer, section 3-1.
   e) If the specified pile tips are below the groundwater table or wet construction methods will be used, CIDH piles shall be designed at a diameter equal to or greater than 600 mm (24 in). Refer to Memos to Designer, section 3-1.
   f) When permanent steel shells for CIDH piles are used to develop a portion of the axial and/or lateral capacity, the shells shall be installed by driven methods using impact hammers only. Refer to Memos to Designer, section 3-1
   g) When permanent casings for CIDH piles are used and will not carry axial and/or lateral loads, the report shall state this.
   h) When a single column is supported on a single CIDH pile, the cut-off elevation used in design shall to be cited in the pile data table.
   i) Refer to "CIDH Pile Design Guidelines" for additional guidance.

5) Special Considerations for Driven Piles
   a) When open-ended CISS piles are recommended, center relief drilling shall be addressed.
   b) Minimum soil plug use for the design of end bearing, etc, shall be addressed.
   c) Drilling to assist driving (Standard Specs 49-1.05) for driven piles may have impacts on the vertical and lateral capacities. These impacts are to be addressed in the Foundation Report. A pile load test program may be considered in such cases.
   d) **(This section is currently being updated for use of the "Gates" equation)**~~Use of the Engineering News Record (ENR) Formula~~
      ~~i) A pile driving formula such as the ENR equation, as adopted in Section 49-1 of *Standard Specifications* (Caltrans, 1999d), may be used to verify bearing capacity for driven piles (note: the equation in Section 49-1 gives a bearing value, known as a safe load, which shall not be less than the design load shown in the PDT in the Contract Plans and Foundation Report). In every such formula the calculated ultimate bearing capacity relies on the penetration length under the last stroke or fall of the hammer, which leads to the conclusion that the ultimate bearing capacity of piles is practically independent of depth. This inherent feature demonstrates that any pile-driving formula is not suitable to friction piles in soft silt or clay where the end bearing is usually disregarded. Even for end-bearing piles and combination piles which the penetration resistance increases with depth, the~~

~~geotechnical professional should be aware of the limitation of the use of any pile driving formula to predicate the ultimate bearing capacity of driven piles.~~

6) Pile Load Testing **(This section is currently being updated)**

Pile Load Testing (PLT) can be used for determining pile capacity at and for establishing field acceptance criteria. A load test remains the definitive way to determine if the geotechnical designers calculated capacity at the specified tip elevations is correct.

When pile load tests are conducted, results may be used for establishing field acceptance criteria for production piles in conjunction with use of wave equation analyses, PDA, or CAPWAP (Case Pile Wave Analysis Program).

Pile load tests should be performed for unusual site conditions, important bridge structures, large-diameter driven piles or large-diameter CIDH (diameter equal to or greater than 1.2 m) piles, foundations supported by one or a few large-diameter pile(s) (with little redundancy), or combination of above. Pile load tests shall be recommended by the geotechnical professional with concurrence of the structural designer. When pile load tests are recommended, a table summarizing pile load test locations, control locations, types of load tests (compression, tension, or lateral loads), STEs, and Nominal Resistances shall be specified in the foundation report.

When a pile load test is performed, the Caltrans acceptance criterion is a maximum of 13 mm (0.5 in) of vertical movement at the top of the pile at the required Nominal Resistance both for compression and tension, refer to Bridge Memo to Designer 3-1.

The equipment and procedures for conducting pile axial compressive load tests can be found in literatures such as *ASTM D 1143*. Static axial tension tests shall be performed per *ASTM D 3689*. Static lateral load tests shall be performed per *ASTM D 3966*.

Whenever pile load tests, wave equation analyses, and pile driving is monitored by PDA on a construction project that is locally administered, the foundation report is to state that copies of the field test results, analyses and drawings of locations of tested piles (or copies of pertinent contract plan sheets) must be submitted by the Local Agency Resident Engineer (or its consultant construction contract administrator) to Caltrans. A cover letter must accompany the load test results that states the Bridge Name, Bridge Number, the pile load test location, Contract EA number, the name and address of the contractor/consultant firm that performed the pile load tests, and the date that the tests were performed. The Caltrans Oversight Structure Representative requires a copy of the cover letter only. For construction projects that are State-advertised and administered, Caltrans' Foundation Testing Branch, of the Office of

Geotechnical Support, Geotechnical Services, will perform the pile load tests and file a copy of the test results, analyses, and drawings.

7) Other Considerations
   a) When steel piles/shells are used in corrosive environments, corrosion mitigation measures shall be required. Caltrans typically includes a corrosion allowance (sacrificial metal loss) for steel piles in corrosive environments. Other corrosion mitigation measures may include coatings and/or cathodic protection. Information regarding corrosion mitigation measures for steel piles is available in Corrosion Guidelines, Version 1.0, (Caltran, 2003). This document may be obtained from the Corrosion Technology Branch, of Materials Engineering and Testing Services, Division of Engineering Services or on the web at www.dot.ca.gov/hq/esc/Translab/metspubs.htm..
   b) When designing pile foundations for earthquake loading where scour conditions exist, the design is to assume that all degradation scour and none of the maximum anticipated local scour (local pier and local contraction) has occurred, per Section 4.4.5.2 of *Bridge Design Specifications* (Caltrans, 2000).
   c) Passive soil resistance around the bent cap shall be neglected unless detailed soil information from field exploration is available in that area. The area of structure backfill surrounding a bent is typically limited; therefore native soil properties shall be used in determining passive soil resistance around the bent cap.
   d) Engineering analyses and calculations shall be legible, coherently organized, and included in Appendices.
   (For internal Caltrans documents: Item “d” is not to be included within the foundation report, but do need to be archived in the bridge folders.)

3.9.3 Approach Fill Earthwork, the geotechnical professional shall address, but not be limited to, the following when applicable:

1) Approach Fills
   a) Expansive Soils - the potential expansion of in-place or imported fill materials shall be addressed. Expansive soil materials shall not be placed as part of the embankment within the limits of a bridge abutment for the full width of the embankment. Expansive soil materials for this requirement are defined as having either an Expansion Index (EI) greater than 50 (EI to be determined in accordance with *ASTM D 4829*), or a Sand Equivalent (SE) less than 20 (SE to be determined in accordance with California Test 217). This requirement is exclusive of the structure backfill and pervious backfill material requirements as shown on the plans and set forth under Sections 19-3.06 and 19-3.065, respectively, in the *Standard Specifications* (Caltrans, 1999~~d~~). Refer to Section 5, Figure 5.4 for the minimum limits for non-expansive soils within an embankment near a bridge.
   b) When unsuitable materials exist at the site, the Foundation Report must address removal, replacement and or re-compaction. The vertical and horizontal limits are to be addressed in the Foundation Report.

2) Approach Fill Settlements - When newly placed approach fills induce consolidation settlement, the geotechnical professional shall provide the following information and recommendations:
   a) Estimates of the magnitudes of settlement,
   b) Required waiting periods/time delay for primary settlement to occur,
   c) Recommendations for surcharge loading and reduced waiting periods when applicable,
   d) When the rate of consolidation of approach fills is controlled by weak underlying soils, rates of loading along with site monitoring (piezometers) shall be specified, and
   e) Recommendations for monitoring fill settlement such as settlement monuments or settlement platforms need to be recommended.
      i) Settlement monuments when only waiting for primary settlement to cease.
      ii) Settlement platforms when waiting for a magnitude of settlement to occur.

3) Additional Considerations - The geotechnical professional shall provide discussion if any of the following is applicable:
   a) Use of lightweight fill to reduce the magnitude of settlement
   b) Use of wick drains or sand drains to accelerate settlement
   c) Use of Geo-synthetic materials to improve shear strength and/or drainage
   d) Use other soil improvement technology (densification, grouting, etc.)
   e) Recommendations of vegetation or pavement for embankment side slopes and bridge approaches
   f) Slope protection
   g) Pre-drilling for any piles through existing embankments (when Standard Specifications 49-1.06 does not apply),
   h) Drilling to assist driving, (Standard Specifications 49-1.05) when required for pile installation.

3.10 Slope Stability Analyses

The overall stability of bridge footings adjacent to or on a slope shall be evaluated for both static and dynamic loading conditions.

(The above does not apply to bridge abutment footings constructed on newly constructed embankments)

Minimum required factors of safety for static conditions are specified in Section 4.4.9 of *Bridge Design Specifications* (Caltrans, 2000).

Pseudo-static analyses may be used to determine slope stability, provided the soils are not liquefiable or expected to lose shear strength significantly during deformation. Pseudo-static analyses shall add (to other forces acting on the element) a horizontal force equal to the element weight times the following: a seismic factor equal to one third of the horizontal peak acceleration and not exceeding 0.2g. The effects of vertical acceleration may be omitted. Sites with a pseudo-static factor of safety equal to or greater than 1.1 shall be considered to have adequate stability and require no further stability analyses.

Sites with a pseudo-static factor of safety less than 1.1 will require dynamic displacement analysis (e.g., Newmark-type analysis). The displacement analysis shall determine the magnitude of potential ground movement for use by the structural designer in determining its effect upon the performance of the structure to meet the design performance level. Iteration may be needed for soil-structure interaction analysis.

Slope instability caused by lateral spreading/global instability due to liquefaction shall be considered if applicable. These analyses can be incorporated with an evaluation for a particular foundation type (see **Section 3.8**).

3.11 General Notes to Designer (This section is currently being updated)

Following are examples of notes that may be included within this section

1) The structure engineer shall show on the plans, in the pile data table, the minimum pile tip elevation required to meet the lateral load demands.
2) Should the specified pile tip elevation required to meet lateral load demands exceed the specified pile tip elevation given within this report, the Office of Structural Foundations should be contacted for further recommendations.
3) Type "D" excavation is to be shown on the plans at Bent(s) __ location(s).
4) Type "A" excavation is to be shown on the plans at Pier(s) __ location(s).
4) Support locations are to be plotted on the Log of Test Borings, in plan view, as stated in "Memos to Designers" 4-2. The plotting of the support locations should be made prior to the foundation review.

3.12 Construction Considerations

The construction considerations are specific notes that are intended for the State's specification writers, construction personnel and potential bidding contractors. The construction considerations identify relevant Standard Specifications and important design criteria that were used in the geotechnical design of the foundations. In addition, the construction considerations should identify subsurface conditions that will be encountered in the field during construction. Specific notes regarding the job site geology are to be included within the construction considerations section to ensure that both the intent of the geotechnical design is met and construction of the foundation elements is successful. Clear and concise notes will help in eliminating potential "Differing Site Conditions" claims.

Construction considerations in the Foundation Report may be needed to address.

1) Control of groundwater and seepage during construction, in order to:
    a) Provide a dry excavation,
    b) Increase the stability of excavations, cut slopes, open-pits, or approach fills,
    c) Improve the strength of foundation materials,
    d) Reduce the lateral loads on supports in an excavation,
    e) Prevent bottom heave and piping,
    g) Accelerate consolidation and settlement, and
    h) Provide for effects due to fluctuations of the water table.

2) Proposed control excavation methods requiring unusual techniques. These may include shoring, sheeting, bracing, special procedures, and variations in types of materials encountered.

3) Pile cut-off.
When driven piles develop the required compressive capacities before reaching the STE, the Contractor may be given the option, with the Resident Engineer's approval, to stop driving and cut off the piles as long as the piles have achieved all the other design tip elevations controlled by tension, lateral, scour, and/or liquefaction and the structural capacity of the piles has not been compromised. For maximum pile cut-off length refer to the *Standard Plans* (Caltrans, 1999).

4) Effects of construction work on adjacent structures.
Efforts shall be made to minimize effects of construction work on adjacent structures. These situations may result from pile-driving vibration, settlement due to de-watering or excavation, or caving due to CIDH pile drilling. A monitoring program may be required for pile driving at, or adjacent to, existing structures that are susceptible to damage or sensitive to noise and/or vibration to assure a presumptive threshold will not be exceeded. If such hazards exist, protection measures against damage shall be discussed.

5) Anticipated construction problems with CIDH piles….

3.13 Disclaimer and Contact Information. **(This section is currently being updated)**

Following is and example from a Caltrans internal document.
The recommendations contained in this report are based on specific project information regarding structure type, location, and design loads that have been provided by the Office of ________. If any conceptual changes are made during final project design, the Office of Geotechnical Design- ________, Design Branch _ should review those changes to determine if these foundation recommendations are still applicable. Any questions regarding the above recommendations should be directed to the attention of (Joe Dirt), (916) 227-YYY-XXXX (CALNET 498-XXXX), or (Dirt Doctor), (916) 227-ZZZZ (CALNET 498-ZZZZ), at the Office of Geotechnical Design- _____ , Branch __.

3.14 Appendices

As an integrative part of the Foundation Report, appendices provide detailed information supporting foundation design, analyses, recommendations, and construction considerations. These shall contain, but not to be limited to the following:
(For internal Caltrans documents, the following 3 appendix items do not need to be included within the foundation report. These items do need to be archived in the bridge folders.)

3.14.1 Appendix I - Site Map, Field Exploration, and Log of Test Borings

1) Site map indicating project location;
2) Data acquired from field exploration such as surface geologic mapping and surface geophysical surveys, logs from Cone Penetration, Pressuremeter,

Dilatometer, and in-situ Vane Shear Tests, Borehole Geophysical logging, Foundation Load Tests, Piezometer Readings, etc.

3) Full-sized Log of Test Borings sheets, including As-Built LOTB.

3.14.2 Appendix II - Laboratory Testing Results

1) Descriptions of each type of soil test and a summary of the results,
2) Geotechnical soil laboratory test results, and
3) Corrosion test results.

3.14.3 Appendix III - Analyses and Calculations

Engineering analyses and calculations supporting the foundation recommendations shall be included. Legible, coherent, and numbered calculation sheets shall contain the dates and initials of the geotechnical professional who performed or checked the analyses and calculations. These shall include, but not to be limited to the following:

1) Bearing capacity, stress distribution, settlement, sliding resistance, uplift, and overall stability calculations for spread footings; vertical, horizontal, rotational, and/or torsional soil springs and damping ratios for footings as required by structural designers;
2) Axial pile capacity and settlement calculations: compression, tension, down-drag force, considerations for potential liquefiable soil and maximum scour depth, and/or group pile capacity and settlement; graphic presentation of proposed axial pile capacity along pile length;
3) Estimated driving resistance: when specific pile tips are controlled by lateral demand, presence of liquefiable soil, down-drag force, and/or scour consideration;
4) Lateral pile capacity calculations: input parameters or files for COM624/LPILE/GROUP or an equivalent analysis, considerations and/or assumptions for the lateral soil modulus parameter (k), soil strain parameter (ε_{50}), p-y curves for liquefiable soils and weak rocks, distributed lateral soil pressures along pile lengths due to slope instability, lateral forces due to liquefaction, reduction factors or efficiency for pile groups, pile head boundary conditions, and loads; summary output plots (not entire output data) including deflection, moment, and shear profiles along pile length, pile head force versus pile head deflection and pile maximum moment as appropriate, point of pile fixity as required by structural designers; p-y, t-z, and Q-Z curves as required by structural designers;
5) Liquefaction evaluation: assumptions, references for correlation relationships, and conclusions; foundation support locations and zones (e.g., bents, stations, and elevations) subjected to the liquefaction hazard shall be listed or tabulated;
6) Slope stability analysis: input files including soil cross-section profiles for STABL or an equivalent analysis, analytical models and assumptions for estimating permanent deformation under static and dynamic loading conditions;
7) Soil resistance against abutments;
8) Settlement calculations for approach fills: type and amount of settlement as well as settlement period with or without pre-loading and/or de-watering; and
9) Recommended *SDC* response spectra or modified versions.

4. LOG OF TEST BORING (LOTB) SHEETS

LOTB and As-Built LOTB sheets shall be prepared and included in the Contract Plans. Examples of prepared LOTB sheets and As-Built LOTB sheets are shown in the documents "SampleLOTB" and "SampleAsBuiltLOTB."

4.1 Check List for Preparation of LOTB Sheets

LOTB sheets shall be drafted in accordance with Section 15-3 of *Bridge Design Aids* (Caltrans, 1989) and Section 2-2.24 of *Plans Preparation Manual* (Caltrans, 2001). LOTB sheets should be checked by the person who performed the field investigation and approved by a Registered Civil Engineer or Registered Geologist, either of whom shall have experience in foundation engineering. The LOTB sheet shall contain, but not to be limited to the following:

1) **Signature Block (Upper Right Corner)**
   a) The State of California Registered Civil Engineer or Registered Geologist seal with the signature, date, license number, and registration certificate expiration date of the engineer or geologist in charge of the foundation study;
   b) Caltrans District, County, and Route;
   c) Name and address of consultant firm performing the foundation investigation (if applicable);
   d) Name and address of the lead local agency (if applicable); and
   e) A disclaimer stating "The State of California or its officers or agents shall not be responsible for the accuracy or completeness of electronic copies of this plan sheet."

   Kilometer Post Total Project limits, Sheet Number, Total Sheets, and Plans Approval Date shall be provided by the Office Engineer.

2) **Legend Block (Left Side)**
   a) Consistency/relative density classification for granular and cohesive soils according to Standard Penetration Test (SPT);
   b) A legend of the earth materials;
   c) A note such as "Visual classification of earth materials is based on field inspection and is confirmed or revised with laboratory test results as necessary;"
   d) A legend of in-situ, lab, and field test designations; and
   e) A legend of types of borings and boring operations.

3) **Title Block (Bottom, from left to right)**
   a) Notes stating "ENGINEERING SERVICES" and "GEOTECHNICAL SERVICES." For consultant-prepared LOTB sheets, instead of those notes, show the name of the Design Oversight (i.e., OSFP/OSCM Senior Liaison) Engineer and sign-off date.
   b) The name of the person preparing the LOTB sheet and the name of the person checking the drawing;
   c) The name(s) of the field investigator(s);
   d) A note stating "STATE OF CALIFORNIA, DEPARTMENT OF TRANSPORTATION" with a scale below the sub-block and a label on the left side stating "ORIGINAL SCALE IN MILLIMETERS FOR REDUCED PLANS."

For consultant-prepared LOTB sheets, the note shall state "PREPARED FOR THE STATE OF CALIFORNIA, DEPARTMENT OF TRANSPORTATION."

e) A note stating "STRUCTURE DESIGN." For consultant-prepared LOTB sheets, instead of this note, show the name of the Project Engineer;
f) The Caltrans Contract Expenditure Authorization (CU and EA) numbers;
g) The State-assigned Bridge (or Structure) Number, Kilometer Post, and the State-assigned Bridge (or Structure) Name;
h) The initial drawn by and subsequent revision dates; and
i) A label stating "LOG OF TEST BORINGS _ OF _" (if applicable). The project LOTB sheets (and Rock Legend sheet, if applicable) shall be followed by As-Built LOTB sheets when applicable.

The Sheet Number and Total Sheets Number will be provided by the Office Engineer.

4) Plan View

a) Plan View is to be shown at the top of the first LOTB sheet. When the site is sufficiently large or complex, the first LOTB sheet may be used entirely for the Plan View.
b) When multiple LOTB sheets are drafted, they shall be numbered with reference to the stationing of the control line (i.e., showing sheet No. 1 with the lowest stationing and the last sheet with the highest stationing).
c) A distinct Plan View of the project site that is independent of the Profile View shall be shown on the LOTB.
d) Show the location, description, and elevation of the benchmark used for determining the top of boring elevations at the top left side of the Plan View.
e) Identify the vertical datum (National Geodetic Vertical Datum, U.S. Geological Survey, U.S. Coast & Geodetic Survey, District, etc.) used to determine the benchmark elevations.
f) Show the scale directly below the Plan View label.
g) Show a North arrow.
h) Lines or control lines shown in the Plan View shall be consistent with those shown on the General Plan sheet.
i) Show a minimum of two stations on all lines.
j) Show stationing and names for control lines. Stationing shall increase from left to right.
k) Show control line intersection stationing and bearings.
l) Show names and directions of nearest cities.
m) Show names and directions of stream flows when applicable.
n) Show the beginning of curve (BC) stationing and end of curve (EC) stationing. When BC and EC locations are beyond the View limits, their locations shall be noted in the Plan View.
o) Plot boring locations with symbols as shown in the legend to identify drilling methods (e.g., auger hole, bucket hole, rotary, cone penetration).
p) Boring locations are to be identified by reference line, station, and offset. Coordinates, such as Northing and Eastings, may also be shown on the LOTB sheets.
q) Borings shall be uniquely numbered for each project.

5) Elevation View

a) Show the control line, increasing from left to right, horizontally across the bottom of the Profile View.
b) Borings shall match the numbering shown in the Plan View.
c) Show the boring's number, top of hole elevation, stationing, and offset at the top of each boring log.
d) Show types and diameters of each boring as shown in the legend.
e) Show the completion date of boring at the bottom of each boring log.
f) Show dates and elevations of groundwater readings.
g) When groundwater was encountered in a boring but no attempt was made to measure the groundwater elevation, a note t this fact is to be included on the LOTB sheet and reference to near by borings where the groundwater surface was measured is to be made.
h) Show results from field tests and results from moisture and density tests at relevant elevations along the boring log.
i) Show types of laboratory tests, with symbols as indicated in the legend, at relevant elevations along the right side of the boring log.
j) Show results from any other in-situ testing or logging (suspension logging, electric logging, etc.).
k) Show the approximate current ground surface line. Future fills shall not be included.
l) Show the Profile metric scales (horizontal and vertical).

6) Additional information to be included when applicable

a) Soil and rock logging system.
b) Rock Legend Standard Sheet.
c) Descriptions of types of sampler used for the field exploration, along with inside and outside diameters of the samplers.
d) Descriptions of hammer type and weight, lift and drop method, and drop height.
e) Metric units shall be used for all LOTB sheets when design is in metric.
f) A "Metric" symbol must be placed next to the signature block for metric jobs.

4.2 Check List for Preparation of As-Built LOTB Sheets

The As-Built LOTB sheet(s) shall be prepared and included in the Foundation Report and Contract Plans for widening, replacing, or retrofitting existing bridges when existing LOTB sheets are available. For a new structure to be constructed in close proximity of an existing structure, the As-Built LOTB sheet(s) of the existing structure may be included with the new set of plans, especially if the foundation information was used to develop recommendations in the Foundation Report. In preparing a copy of the As-Built Log of Test Borings sheet, use a process that will result in a final black line reproducible sheet of a high quality.

1) Obtaining and Reproducing the As-Built LOTB Sheet

a) Reproducible copies of As-Built LOTB sheets may be obtained from the Microfilm Services Units in the Caltrans District Offices. If the As-Built LOTB sheets provided to Local Agencies or consultants by the Caltrans District Offices are not legible, a full sized copy can be requested from Geotechnical Services.

b) As-Built LOTB sheets shall be size "D" (24" by 36"). The As-Built LOTB title block shall be sized to fit and placed at any open space (preferably toward the top) on the As-Built LOTB sheet.
c) Information on the As-Built LOTB sheet shall be as clear and legible as possible. In order to improve the legibility of the information, it may be necessary to darken the line work and the notations.

2) Typical Modifications to As-Built LOTB Sheets

a) Show a "Metric" notation next to the signature box if any metric conversion, notation, or notes have been made.
b) If As-Built LOTB sheets are shown in imperial units, the offset and stationing location of each boring must be converted to metric. A table shall be added showing the dual dimensions (Metric and English) of each boring. The table shall show the station and offset in relation to the new metric line. The General Plan will show the current metric control line.

3) The As-Built LOTB Title Block (Figure 2) shall include the following information for the current project

a) A note stating "GEOTECHNICAL SERVICES -- DIVISION OF ENGINEERING SERVICES" (if applicable).
b) Caltrans District, County, Route, Kilometer-Post Total Project limits, State-assigned Bridge (or Structure) Number and Name, and Expenditure Authorization (CU and EA) numbers. The Sheet Number and Total Sheets Number will be provided by the Office Engineer.
c) The State of California Registered Civil Engineer or Registered Geologist seal with the signature, date, license number, and registration certificate expiration date of the engineer or geologist in charge of the foundation study.
d) A note stating "As-Built Log of Test Borings sheet is considered an informational document only. As such, the State of California registration seal with signature, license number and registration certificate expiration date confirm that this is a true and accurate copy of the original document. It does not attest to the accuracy or validity of the information contained in the original document. This drawing is available and presented only for the convenience of any bidder, contractor or other interested party."
e) A sub-box stating "LOG OF TEST BORINGS _ OF _" (if applicable).
f) A note stating "A COPY OF THIS LOG OF TEST BORINGS IS AVAILABLE AT OFFICE OF STRUCTURE MAINTENANCE AND INVESTIGATIONS, SACRAMENTO, CALIFORNIA" (if applicable).

Examples of ~~LOTB~~ and As-Built LOTB sheets are shown in the documents "~~Sample LOTB~~" and "Sample As-Built LOTB". Additional information regarding LOTB and As-Built LOTB sheets can be found in Section 15-3 of *Bridge Design Aids* (Caltrans, 1989), Section 2-2.24 of *Plans Preparation Manual* (Caltrans, 2001) *and Drafting and Plans Manual of Instruction* (Caltrans 1996).

(The sample "LOTB" sheet that may be down loaded is currently being updated. The document available for down loading is not in conformance with current Caltrans standards for Log of Test Boring sheets.)

5 FIGURES

Figure 5.1. Soil Corrosion Data Table, (Example)

Soil Corrosion Test Summary

Location	SIC Number	Minimum Resistivity (Ohm-Cm)	pH	Chloride Content (ppm)	Sulfate Content (ppm)

Note: Caltrans currently considers a site to be corrosive to foundation elements if one or more of the following conditions exist: Chloride concentration is greater than or equal to 500 ppm, sulfate concentration is greater than or equal to 2000 ppm, or the pH is 5.5 or less.

Figure 5.2. Spread Footing Data Table, (Refer to MTD for most current example)

Spread Footing Data Table

Support Location	Minimum Footing Width	Bottom of Footing Elevation	Recommended Bearing Limits	
			WSD[1]	LFD[2]
			Allowable Bearing Capacity (q_{all})	Nominal Bearing Resistance (q_n)
Abut 1			XX kPa (YY ksf)	N/A
Bent 2			N/A	XX kPa (YY ksf)
Pier 3			N/A	XX kPa (YY ksf)
Abut 4			XX kPa (YY ksf)	N/A

Notes: 1) Working Stress Design (WSD). The Maximum Contact Pressure (q_{max}) is not to exceed the Recommended Gross Allowable Bearing Capacity (q_{all}).
2) Load Factor Design (LFD). The Maximum Contact Pressure (q_{max}) divided by the Strength Reduction Factor (ϕ) is not to exceed the Nominal Bearing Resistance (q_n).

Figure 5.3. Pile Data Table, (Refer to MTD for most current examples)

Location	Pile Type	Design Loading	Nominal Resistance		Design Tip Elevations	Specified Tip Elevations
			Compression	Tension		
Abutment 1						
Bent 2		N/A				
Abutment 3						

Design tip elevation is controlled by the following demands:
(1) Compression, (2) Tension, (3)…..

Figure 5.4. Typical Section: Expansive Soil Exclusion Zone in Bridge Embankment

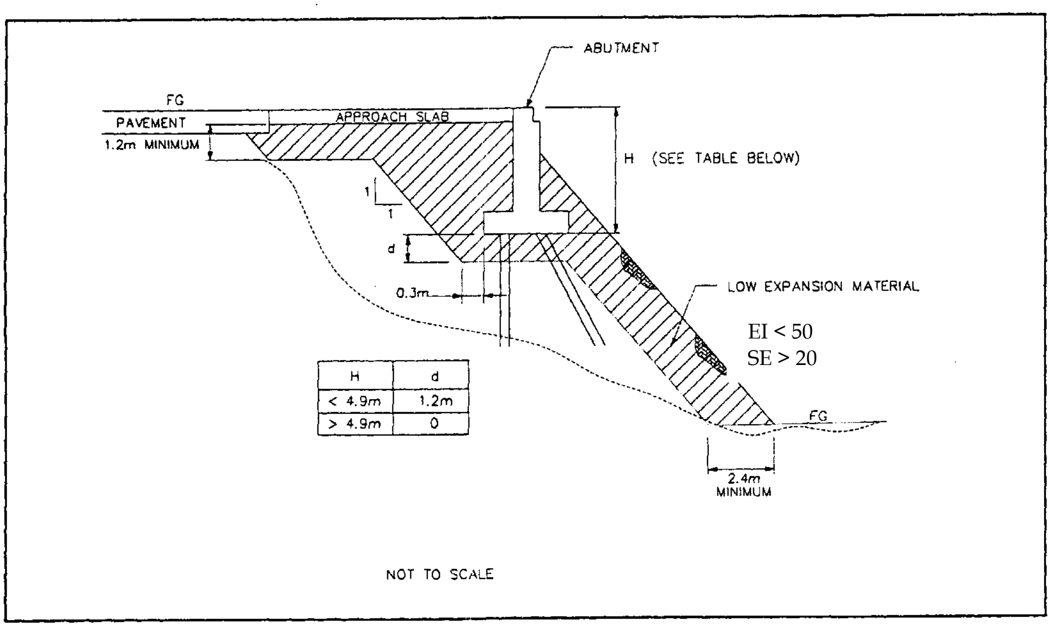

Figure 5.5. Title Block for As-Built Log of Test Borings

GEOTECHNICAL SERVICES -- ENGINEERING SERVICES					
As-Built Log of Test Borings sheet is considered an informational document only. As such, the State of California registration seal with signature, license number and registration certificate expiration date confirm that is this a true and accurate copy of the original document. It does not attest to the accuracy or validity of the information contained in the original document. This drawing is available and presented only for the convenience of any bidder, contractor or other interested party.					
DIST.	COUNTY	ROUTE	KILOMETER POST – TOTAL PROJECT	SHEET NO.	TOTAL SHEETS
08	SBd	210	10.00-15.00	24	25
Date REGISTERED ENGINEER – CIVIL					
MAIN STREET OVERCROSSING					
LOG OF TEST BORINGS 5 OF 6					
NOTE: A COPY OF THIS LOG OF TEST BORINGS IS AVAILABLE AT OFFICE OF STRUCTURE MAINTENANCE AND INVESTIGATIONS, SACRAMENTO, CALIFORNIA				CU: 01234 EA: 12-345678	BRIDGE NO. 12-3456

6. REFERENCES

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